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NEW UTILITY PATENT APPLICATION TRANSMITTAL

(to be used for new applications only)

Attorney Docket Number	MJV-108-B
First Named Inventor	Jorge A. Morando
Total Pages in this Submission	

01/12/98 JC557 U.S. PTO

APPLICATION ELEMENTS

Notice: Checklist items mentioned under Application Elements section construct a new utility patent application. Please refer to MPEP Sections 506, 601, (37CFR 1.77, 1.53, 35 USC 111, 112, 113) for detailed explanation regarding completeness of an original patent application.

1. [X] Fee Transmittal Form (prescribed filing fee(s))
2. Specification
   - [X] Title of the Invention
   - [X] Cross References to Related Applications *(if applicable)*
   - [ ] Statement Regarding Federally-sponsored Research/Development *(if applicable)*
   - [ ] Reference to Microfiche Appendix *(if applicable)*
   - [X] Background of the Invention
   - [X] Brief Summary of the Invention
   - [X] Brief Description of the Drawings *(if drawings filed)*
   - [X] Detailed Description
   - [X] Claim or Claims
   - [ ] Abstract of the Disclosure
3. [X] Drawing(s) *(when necessary as prescribed by 35 USC 113)*
4. [X] Executed Declaration
5. Genetic Sequence Submission *(if applicable, all must be included)*
   - [ ] Paper Copy
   - [ ] Computer Readable Copy
   - [ ] Statement Verifying Identical Paper and Computer Readable Copy

ACCOMPANYING APPLICATION PARTS

6. [ ] Assignment Papers
7. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
8. [ ] Computer Program in Microfiche
9. [ ] English Translation Document *(if applicable)*
10. [ ] Information Disclosure Statement/PTO-1449 [ ] Copies of IDS Citations
11. [ ] Petition Checklist and Accompanying Petition
12. [ ] Preliminary Amendment
13. [ ] Proprietary Information
14. [X] Return Receipt Postcard
15. [X] Small Entity Statement
16. [X] Additional Enclosures *(please identify below):*

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm or Individual name	Charles W. Chandler
Signature	
Date	1/7/98

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Application Number			Class		Independent Claims		
Date of Receipt	Application Type		GAU		Total Claims		
	Filing Date		Foreign Filing License?		Drawing Sheets		
	Small Entity		Foreign Address?		Special Handling?		

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FEE TRANSMITTAL

TOTAL AMOUNT OF PAYMENT	($) 694.00

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	Jorge A. Morando
Group Art Unit	
Examiner Name	
Attorney Docket Number	MJV-108-B

METHOD OF PAYMENT (check one)

1. ☐ The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:

Deposit Account Number:
Deposit Account Name:

☐ Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17

☐ Charge the Issue Fee Set in 37 CFR 1.18 at the Mailing of the Notice of Allowance, 37 CFR 1.311(b)

2. ☒ Payment Enclosed:
☒ Check ☐ Money Order ☐ Other

FEE CALCULATION (fees effective 10/01/95)

1. FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	750	201	375	Utility filing fee	395
106	310	206	155	Design filing fee	
107	510	207	255	Plant filing fee	
108	750	208	375	Reissue filing fee	
114	150	214	75	Provisional filing fee	

SUBTOTAL (1) ($) 395.

2. CLAIMS

			Extra		Fee from below	=	Fee Paid
Total Claims	36	-20 =	16	X	11	=	176.
Independent Claims	6	- 3 =	3	X	41	=	123.
Multiple Dependent Claims				X		=	

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	22	203	11	Claims in excess of 20
102	78	202	39	Independent claims in excess of 3
104	250	204	125	Multiple dependent claim
109	78	209	39	Reissue independent claims over original patent
110	22	210	11	Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 299.00

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet.	
139	130	139	130	Non-English specification	
147	2,390	147	2,390	For filing a request for reexamination	
112	870*	112	870*	Requesting publication of SIR prior to Examiner action	
113	1,740*	113	1,740*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for response within first month	
116	380	216	190	Extension for response within second month	
117	900	217	450	Extension for response within third month	
118	1,400	218	700	Extension for response within fourth month	
119	290	219	145	Notice of Appeal	
120	290	220	145	Filing a brief in support of an appeal	
121	250	221	125	Request for oral hearing	
138	1,430	138	1,430	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive unavoidably abandoned application	
141	1,250	241	625	Petition to revive unintentionally abandoned application	
142	1,250	242	625	Utility issue fee (or reissue)	
143	430	243	215	Design issue fee	
144	630	244	315	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	220	126	220	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	750	246	375	Filing a submission after final rejection (37 CFR 1.129(a))	
149	750	249	375	For each additional invention to be examined (37 CFR 1.129(b))	
				Other fee (specify)	
				Other fee (specify)	

SUBTOTAL (3) ($)

*Reduced by Basic Filing Fee Paid

SUBMITTED BY				Complete (if applicable)	
Typed or Printed Name	Charles W. Chandler			Reg. Number	24,290
Signature		Date	1/7/98	Deposit Account User ID	

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JET COLUMN REACTOR PUMP WITH COAXIAL AND/OR LATERAL INTAKE OPENINGS

Cross-Reference to Related Applications

This application is a continuation-in-part of application serial no. 08/733,078 filed October 16, 1996 for Monolithic Jet Column Reactor Pump, which in turn was a continuation-in-part of U.S. application serial no. 08/489,322 filed June 12, 1995 for a Bubble Apparatus for Removing and Diluting Dross in a Steel Treating Bath, and which has since issued as United States Patent No. 5,683,650 on November 4, 1997; and Provisional Patent Application No. 60/041,146, filed March 17, 1997, for Method and Apparatus for Injecting a Gas Into a Bath of Molten Metal.

Background of the Invention

This invention pertains to an improved gas jet operated pump for moving a liquid such as molten metal in a bath of such liquid, and more particularly to such a pump in which a gas jet is introduced along the direction of motion of the metal in a liquid transfer passage where the liquid intake is through openings in the back and side wall of the liquid transfer passage.

In my aforementioned patent applications, I disclosed a pump for moving molten metal between two spaced locations in a molten metal bath by introducing the molten metal axially through the lower inlet end of a conduit, raised by a gas jet momentum which expands to form metal-lifting bubbles and then removed through an upper outlet opening of the conduit.

Other prior art devices introduce the gas radially through the side wall of the metal-lifting passage, perpendicular to the flow of metal. The direction the gas is

introduced into the metal-lifting passage affects pump performance. Gas bubbles draw the metal through the bottom inlet opening of the pumping conduit, while the gas being injected to form those bubbles may oppose the metal motion.

Summary of the invention

The broad purpose of the present invention is to provide an improved gas jet column operated apparatus for moving a liquid, such as molten, metal either between two spaced locations in a bath of the liquid or in a strong stream out of the bath.

An example of such apparatus includes a ceramic body having an inclined or horizontal internal passage. The gas is introduced as a gas jet into the lower end of the metal-lifting passage in the direction of the rising molten metal.

The momentum of the gas combines with the buoyancy of the bubbles in moving the metal. The high pressure gas momentum can move the metal either upwardly, horizontally or even downwardly.

In another embodiment of the invention, the metal-lifting passage has a convergent/divergent nozzle between the metal intake windows and the upper outlet opening. The convergent/divergent nozzle controls the coalescence of the bubbles rising in the metal-lifting passage. The transfer of momentum of the gas jet generates the flow of metal. The direction of the gas obviates any tendency of the gas jet to block metal flow. Other forms of the invention employ a metal-lifting passage with either a convergent passage, or a divergent passage depending upon the desired flow rate and the head of the liquid.

The principles of the invention can also be used for introducing a gas into a moving stream of a liquid, or for degassing a bath of the liquid.

Still further objects and advantages of the invention will become apparent to those skilled in the art to which invention pertains upon reference to the following detailed description.

Description of the Drawings

The description refers to the accompanying drawings in which like reference characters refer to like parts throughout the several views, and in which:

FIGURE 1 is an elevational view of a gas jet operated molten metal pump illustrating the preferred embodiment of the invention;

FIGURE 2 is a view of the gas jet operated pump from the opposite side of Figure 1;

FIGURE 3 is an enlarged longitudinal sectional view through the preferred gas jet operated pump;

FIGURE 4 is a view as seen along lines 4-4 of Figure 3;

FIGURE 5 is a longitudinal sectional view through another embodiment of the invention employing a convergent/divergent nozzle;

FIGURE 6 is a partially fragmentary view seen from the left side of Figure 5;

FIGURE 7 is an enlarged sectional view of the convergent/divergent nozzle;

FIGURE 8 is an elevational view of another embodiment of the invention incorporating a vertical metal-lifting passage;

FIGURE 9 is a partially fragmentary view as seen from the right side of Figure 8;

FIGURE 10 is a sectional view showing an inclined metal-lifting passage with an internal convergent nozzle;

FIGURE 11 is a view as seen from the right side of Figure 10;

FIGURE 12 is another embodiment of the invention employing a convergent nozzle in a horizontal position with lateral and rear inlet openings;

FIGURE 13 is a view as seen along lines 13-13 of Figure 12;

FIGURE 14 is a view as seen from the left side of Figure 12;

FIGURE 15 is a sectional view through a gas jet operated pump for delivering a liquid in a vertical direction using a divergent nozzle;

FIGURE 16 is a view as seen along lines 16-16 of Figure 15;

FIGURE 17 is a sectional view through another jet operated pump in which the gas is introduced axially through a bottom inlet into the pump transfer passage;

FIGURE 18 is a sectional view as seen along lines 18-18 of Figure 17;

FIGURE 19 is a view of another jet operated pump in which the liquid is delivered downwardly through a divergent passage;

FIGURE 20 is a view as seen along lines 20-20 of Figure 19;

FIGURE 21 is a sectional view of an apparatus for introducing the gas jet through a distribution ring;

FIGURE 22 is an enlarged perspective view of a preferred distribution ring; and

FIGURE 23 is a sectional view of another embodiment in which the pump transfer passage diverges from the distribution ring.

Description of the Preferred Embodiment

Referring to the drawings, Figures 1 and 2 illustrate a preferred gas jet column reactor pump apparatus 10 disposed in a bath of molten aluminum 12 having a metal line 14.

Pump 10 comprises a body 16 formed of a ceramic or other suitable material depending upon the particular molten metal in the bath. In a zinc galvanizing bath, the body can be manufactured from graphite, a stainless steel material, or AT-103 or AT-103A, metallic super alloy materials available from Alphatech Inc. of Cadiz, Kentucky, specifically formulated for resistance to zinc at temperatures up to 1400 degrees Fahrenheit. In Galvalume (aluminum and zinc) or aluminum, the body can be manufactured from any ceramic material resistant to these molten metals or RBSN-AL25, a ceramic material also available from Alphatech Inc. RBSN-AL25 has been proven to be extremely resistant to molten aluminum attack at temperatures up to 1600°F and capable of withstanding up to 5000 thermal shocks from air to molten aluminum at 1480°F.

Body 16 has an internal metal-lifting passage 18 which includes an inclined section 20 connected very gradually to a top generally horizontal section 22. The metal-lifting passage has a uniform elliptical cross section along its length as illustrated in Figures 2 and 4 at outlet opening 24. The outlet opening is formed at an angle of about 30-45 degrees from the vertical as illustrated in Figure 3. The metal-lifting passage has a lower blind end 26.

The inclined portion of the metal-lifting passage is formed along an axis 28 which also defines the path of motion of the molten metal as it rises along the metal-lifting passage.

Referring to Figure 4, seven metal intake windows 30a - 30g are formed in the wall of the metal-lifting passage symmetrically around axis 28. The intake windows

have a sufficient size to receive the incoming molten metal which then passes upwardly in the passage and then horizontally out outlet opening 24.

A vertical ceramic gas feeding tube 38 has a lower end 40 received in a recess 42 in the body and attached to the body. The upper end of gas feeding tube 38 is connected to a bracket 44 which in turn is attached to any suitable support 46 adjacent the container holding molten aluminum 12. The length of the gas feeding tube is sufficient to provide body 16 with a gas feeding passage such that its outlet end is a suitable distance, such as 12-30 inches, below metal line 14.

Gas feeding tube 38 has an internal gas passage for receiving a suitable inert gas, such as nitrogen, in the direction of arrow 48, down through a passage 50 which is connected through a short passage 52 in the body to cross passage 53. Passage 53 has several gas outlet openings (nozzles) 54 spaced along axis 60 (Figures 1 and 4) and connected to metal-lifting passage 18.

Body 16 is supported on a double pair of leg means 56.

The arrangement is such that the gas is injected as a jet into the metal-lifting passage in the direction of motion of the rising molten metal. The gas jets gradually coalesce to form bubbles such as at 64 which entrap and raise segments of the molten metal.

Thus, the embodiment of Figures 1-4 introduces the gas coaxially along the direction of motion of the metal as it rises in the pump. The molten metal is introduced through windows that are in coaxial and lateral positions with respect to the direction of motion of the gas. The transfer to the metal of the gas momentum provides the energy for raising and accelerating the flow of metal.

The pump can be used to re-circulate molten metal in a bath between areas having a difference in temperature, as a pumping device for moving the molten metal from one location in the pot to another for reasons other than changing the temperature differential, such as removing dross by gas dispersion, removing gaseous contaminants, mixing a gas with the molten metal etc.

Figures 5 and 6 illustrate another embodiment of the invention in the form of a pump 100 supported on a refractory, ceramic or graphite pedestal 102 mounted on floor 104 of the pot. The metal, such as molten aluminum 106, is contained in the pot and has a metal level 108. Pump 100 has a tubular body 110 which for illustrative purposes is formed of refractory, ceramic or graphite. The body has an internal metal-lifting passage 112. Passage 112 has an inclined section 114 which merges at its upper end with horizontal section 116 and terminates with outlet opening 118.

As in the embodiment of Figures 1 and 4, the wall of the metal-lifting passage has a plurality of rear and lateral metal-intake windows 120 which introduce the molten metal coaxially and/or at an acute angle with respect to the direction 122 of the metal rising in the lower section of the metal-lifting passage.

A U-shaped gas feeding tube 124, also formed of ceramic or graphite, has a pair of upper ends 126 adapted to receive an inert gas in the direction of arrows 128. The gas passes downwardly through a gas passage 130 where it is injected as a jet through a series of bottom gas inlet openings (gas nozzles) 132 into the metal-lifting passage, in the direction of arrow 134 along axis 122.

Referring to Figure 7, the metal-lifting passage has a convergent/divergent nozzle 136 having the following approximate ratios:

$$W_T = .90\ W_{in} \text{ to } .60\ W_{in}$$

$$W = Width$$

$$W_{in} = \frac{3.50\ in}{4.50\ in};\ L_{in} = \frac{.60\ W_{in}}{.80\ W_{in}};\ L_1 = \frac{.30\ W_{in}}{.50\ W_{in}};\ \text{and}$$

$$L_o = \frac{16.0_{in}}{20.0_{in}} \bullet W_0 = W_{in}$$

$$L = Length$$

The gas jet can be delivered either in a continuous stream or in an intermittent form. In either case, the gas is forcibly diffused into the metal, emerges through nozzles 132 and coalesces in a series of spaced bubbles 138 because of the deceleration of the gas and surface tension. The bubbles rise in the molten aluminum, assisting to entrap sections of aluminum between them, and carry the entrapped sections upwardly toward outlet opening 118.

Figure 8 shows another embodiment of the invention comprising a body 200 formed of graphite, ceramic or other suitable material depending upon the particular metal in the bath. In this embodiment of the invention, body 200 has an internal elliptical passage 202, and a pair of opposed metal-intake windows 204 and 206 formed adjacent its lower blind end 208. The internal passage terminates at its upper end with an outlet opening 210. The major portion of the body is supported in a vertical position as illustrated in Figure 8.

Passage 202 has an internally convergent nozzle 212 which then forms an intermediate section 214 and then a divergent nozzle 216 formed in accordance with the formula of the embodiment of Figure 7. This passage functions in the same manner as the embodiment of Figure 7.

Gas feeding tube 218 has a generally "U" shaped configuration with a pair of vertical legs 220 and 222 having upper inlet ends 224 and 226 for receiving a suitable inert gas such as nitrogen. The gas is delivered downwardly into an internal gas passage 228 which extends from opening 226 to opening 224. A lower horizontal leg 230 is connected to the body beneath the lower end of the metal-lifting passage. Gas passage 228 has three small nozzles 232 for passing the gas from passage 228 into the metal-lifting passage. Although three nozzles 232 are illustrated, a series of small nozzles can be formed to deliver a strong high velocity gas jet to form very small bubbles of gas in the metal-lifting passage.

In this form of the invention, the gas is introduced through the bottom of the metal-lifting passage in the form of a jet and then passes vertically to raise the metal being drawn through intake windows 204 and 206. As the gas passes through the convergent/divergent nozzle, it is initially compressed and then expands to form bubbles so that a combination of the momentum of the gas jets and the buoyancy of the bubbles moves the metal upwardly throughout outlet opening 210.

Figure 10 illustrates still another embodiment of the invention specifically for maintaining high gas/metal flow velocities for dross or gaseous impurities removal purposes. A jet reactor pump 300 has an elongated ceramic body 302. Body 302 has an internal metal-lifting passage 304. Passage 304 is inclined as illustrated and then merges with a generally horizontal outlet opening 306. The bottom end of passage 304 is closed to metal flow. Windows 308 just above the bottom end of the passage form intake openings for the metal.

The internal metal-lifting passage has a convergent nozzle section 310 which narrows down to an elliptical section 312 which is generally uniform from the convergent nozzle to outlet opening 306, to maintain the high metal/gas flow velocity and forcibly accelerate the metal/gas mixing process.

A vertical support leg 314 has its upper end attached to the body and its lower end adapted to be mounted on the floor 316 of the metal bath.

A gas feeding tube 318 of graphite or ceramic has an upper inlet end opening 320 for receiving gas into an internal gas passage 322. Tube 318 is generally "U" shaped with a pair of upright legs 324 and 326. The gas passes downwardly through passage 322 to a series of small gas nozzles 328 which connect gas passage 322 to metal-lifting passage 304. Nozzles 328 are aligned along the longitudinal axis 330 of the lower part of the metal-lifting passage.

Like the embodiment of Figure 8, the gas is introduced axially through nozzles 328 to the metal-lifting passage so that the energy of the gas pushes the metal upwardly through the convergent nozzle. The metal is received through oblique lateral windows 308, passes upwardly through the convergent nozzle and then out through the upper outlet opening. Since the pumping principle does not depend on the gas bubble buoyancy the metal could also be moved by the gas momentum in either a horizontal or a downward direction. In Figure 11 the convergent nozzle section has been created by narrowing the pump body 304 frontally rather than laterally.

Referring to Figures 12 to 14, another embodiment of the invention in the form of gas jet reactor pump 400 has a horizontally elongated tubular body 402 supported on the left end, as viewed in Figure 12, by leg means 404 and 406 on floor 408 of the pot.

Body 402 is below the metal level 410 of the pot. The body may be formed of graphite, ceramic or another suitable material depending upon the particular material in the bath. The body has a generally horizontal axis 410 along which the metal flows. The metal is introduced axially through four inlet openings 412a, 412b, 412c, and 412d as can be seen in Figure 14. Each of the openings 412a - 412d are vertically elongated and deliver the metal in the direction of arrows 414 as viewed in Figure 12.

The body also has a plurality of lateral metal intake openings 416 for receiving metal into the body in the direction of arrows 418. Metal is delivered toward the right as viewed in Figure 12 toward an elliptical outlet opening 420. The body has an internal passage 421 with a generally elliptical cross section with the inlet portion 422 having a larger diameter which is reduced in a tapered section 424 to form a convergent nozzle which merges into a smaller outlet section 426. Dotted lines 428 indicate an optional divergent outlet opening that may be incorporated.

An upright ceramic gas feeding tube 430 is connected at its lower end to a three nozzle manifold 432. The upper end of gas feeding tube 430 extends above metal line 410. Tube 430 has an upright inlet opening 434 for receiving gas in the direction of arrow 436 through an internal conduit 438. The lower end of conduit 438 terminates in a horizontal passage 440 as is best illustrated in Figure 13.

Passage 440 is connected with three nozzles 442, 444 and 446 which are disposed in vertical, horizontally-spaced legs 448, 450 and 452, respectively. Gas enters into the moving metal as a jet from nozzles 442, 444 and 446. Legs 448, 450 and 452 are disposed in the horizontal path of motion of the liquid metal as it is received into metal-lifting passage 421 along axis 410.

In this version, both the gas and the liquid enter the metal-lifting passage along the same axial path of motion. In addition, metal is received through lateral openings 416.

Note also that in the embodiment of Figures 12 to 14, the metal does not rise but moves horizontally between two spaced positions in the pot. The momentum of the metal is caused by the momentum of the gas jet.

Figures 15 and 16 illustrate another form of pump 500 when higher flows and lower output heads are expected. Although this device is described as a pump for moving a liquid, it can also be employed as a device for introducing a gas into a moving liquid, or for de-gassing a liquid such as molten metal.

Pump 500 has an integral body 502 formed of a suitable material with an internal passage 504 for receiving a liquid in the direction of arrows 506 along an axis 508. The pump is oriented so that the liquid is discharged upwardly. However, the pump can be oriented in any direction such as downwardly, horizontally or in any inclined direction.

Passage 504 has a short inlet passage 510 with a circular cross-section, transverse to liquid flow, however the cross-section can be elliptical or have other suitable configurations. Inlet passage 510 has a uniform diameter "A" along its length. Passage 510 forms an inlet to a divergent passage 512 which has a diameter that increases in the direction of liquid flow to an outlet opening 514. Divergent passage 512 is shown with a frusto-conical cross-section, however the cross-section could take other divergent shapes. The outlet end of divergent passage 512 merges with outlet passage 516.

The outlet end of divergent passage 512 has a diameter B that is larger than the inlet end. A suitable pressurized gas source 520 is connected by conduit means 522 to an annular passage 524 in the pump body. Passage 524 has several short gas delivery passage means 526 which terminate in opening means 528 disposed in the wall of divergent passage 512. The gas is delivered through openings 528 in the form of a gas jet at sonic or near sonic velocity to obtain maximum transfer of momentum as the gas rises and to form bubbles which expand to assist in lifting segments of the liquid upwardly toward discharge end 530. The gas can be used either to induce a flow of the liquid through the inlet end, or it can be used for mixing a gas with a liquid in which the liquid flow is induced through other means.

Figures 17 and 18 illustrate another embodiment of the invention similar to that of Figures 15 and 16 in the form of a pump 600. Pump 600 has a body 602 formed of any suitable material with internal passage means 604 for receiving a flow of a liquid through a bottom inlet opening 606. The internal passage has a cylindrical inlet passage 608 connected to a divergent passage 610 which in turn terminates with a cylindrical end 612. The diameter of the inlet end of the divergent passage is smaller than the diameter of outlet passage 614. Although the inlet and outlet sections are illustrated as being cylindrical, they can also have an elliptical cross-section. Similarly, although divergent passage 610 is illustrated as being frusto-conical, it can also be formed with an elliptical cross-section.

The liquid passes upwardly in a vertical flow pattern along an axis 616 to discharge in an upward direction, however, the pump can be oriented in any other suitable position depending upon the direction the liquid is to be discharged.

A gas delivery section 620 is attached to the bottom of the pump and has an elongated gas delivery passage 622 connected to a source of pressurized gas 624. In this case the gas is delivered as a jet to a bottom gas nozzle 626 along axis 616, parallel with the motion of the moving liquid. This pump can also be used for mixing a gas with a moving liquid or degassing a liquid such as molten metal. The gas is introduced as a jet so that its momentum tends to push the liquid toward the outlet opening. The gas then forms bubbles which expand to assist in lifting sections of the liquid upwardly in combination with the gas momentum.

Figures 19 and 20 illustrate another embodiment of the invention which is similar to the embodiments of Figures 15 and 17 and includes a body 700 having an internal passage 702. Passage 702 has a cylindrical inlet section 704 with a diameter "A" but which also could be made with an elliptical transverse cross-section. The inlet passage then merges with a frusto-conical divergent passage 706 which diverges in the direction of liquid flow, and terminates with an outlet end 708 at a short cylindrical passage 710. Passage 706 functions in a manner similar to that of the embodiment of Figure 15.

A vertical gas conduit 712 having an internal gas passage 714 is connected to a source of pressurized gas 716. The gas passes from passage 714 to an annular passage 718 which encircles the pump body. Passage 718 passes the gas through short passage means 720 to nozzle means 722. Nozzle means 722 comprise two nozzles 180° apart, however three nozzles 120° apart will also function adequately. The gas is introduced as a jet into the divergent passage 706 so that the momentum of the gas assists in inducing a liquid flow through inlet section 704. Passage 710 is

connected to a conduit 724 having an internal passage 726 which delivers the gas/liquid mix in a horizontal direction from the lower end of the pump.

Figures 21 and 22 illustrate another device for pumping and simultaneously introducing gas into a bath 810 of liquid aluminum having a metal level 811. Pump 812 has a cylindrical inlet conduit 830 with a threaded end 832. A frusto-conical convergent nozzle 834 is internally threaded at 835 and screwed into conduit 830. Nozzle 834 has an annular seat 836.

A distribution ring 838 is mounted between the outer end of conduit 830 and seat 836. Nozzle 834 has a boss 840 with an inlet opening 846 for seating a conduit 848 which delivers a gas, such as nitrogen or chlorine, from a pressurized source 850. Conduit 830 and nozzle 834 may be of any suitable material such as graphite or ceramic. Distribution ring 838 is made of a material that is compatible with the liquid metal and the gas, such as graphite or ceramic.

The distribution ring has an annular slot 852 aligned with gas conduit 848 for receiving a gas into the slot. The distribution ring has an annular series of spaced openings or nozzles 854 which extend from slot 852 through the downstream face 856 of the distribution ring. Nozzles 854 are disposed at an angle $0° \leq \alpha < 30°$ to deliver the gas in a conical or parallel path at sonic or nearly sonic velocity (whichever is most suited to the application) into the path of metal flow in the direction of arrow 858. This arrangement transfers the gas momentum to the liquid metal thereby increasing the gas dispersion into the metal and improving the pump efficiency.

Convergent nozzle 834 has an internal convergent frusto-conical passage 860 downstream of the distribution ring which also adds to the efficiency of the pump and increases the gas dispersion and the liquid/gas mix velocity.

The distribution ring has an internal frusto-conical passage 862 which is enlarged in the direction of the metal flow to further increase the gas residence time in the liquid. An outlet tube 870 with an internal liquid-lifting passage 872 is attached to the outlet of nozzle 834 to assure gas/liquid contact during the gas coalescence, and in this form to increase the pump flow and gas dispersion capacity.

Figure 23 illustrates still another embodiment of the invention in the form of gas jet operated pump 900 operated in a bath 902 of any suitable liquid having a liquid level 903. The pump is similar to the pump of Figures 21 and 22, however, it includes an inlet conduit 904 having an externally threaded end 906 with a frusto-conical internal convergent inlet passage 908 for receiving a liquid in the direction of arrow 910.

An outlet conduit 912 has an internally threaded boss 914 threadably connected to the end of inlet conduit 904. Outlet conduit 912 has a frusto-conical internal divergent passage 916 which extends from a throat area 918 that extends from convergent passage 908. The outlet conduit then terminates with a cylindrical discharge section 918. The wall of passage 916 preferably forms an angle β with respect to the flow of fluid passing through the inlet toward the outlet. Angle β preferably ranges between $0° \leq \beta < 30°$.

Boss 914 has an integral internal distribution ring section 922 which has an annular array of spaced nozzle means 924 that are disposed about the axis 926 of the frusto-conical passage. The nozzles deliver a gas from a conduit 928 which in turn is

supplied by a source 930 of pressurized gas such as nitrogen, or other suitable gas that is to be mixed with the liquid passing through the pump.

The nozzle means deliver the gas in the direction of arrows 932 which are preferably delivered at an angle α which is the angle between the direction of the gas delivery and the flow path of the liquid. The optimum range of angles for α is 7° to 10°. Angles α and β are chosen depending upon the nature of the fluid, the pressure, the temperature and volume of fluid being delivered.

A discharge conduit 940 having an internal generally S shaped passage 942 is attached to the cylindrical discharge section 918 to raise the liquid from the pump upwardly and then to discharge it in a generally horizontal direction as indicated by arrow 944. The discharge conduit 940 also assists in increasing the gas flow as the gas forms bubbles that rise in the passage 942 to assist the momentum of the gas in moving the liquid.

The embodiment of Figure 23 with a divergent flow passage immediately downstream of the gas nozzles is intended to generate a greater gas expansion to increase the liquid flow while reducing the pressure such as in molten aluminum. The divergent passage (diffuser) generates a higher flow capacity for moving the liquid. The embodiment of Figures 21 and 22 with the convergent full passage immediately downstream of the gas nozzle is intended to generate a higher pressure head for raising the liquid, or increasing the gas dispersion into the liquid.

Having described my invention, I claim.

Claims

1. In a metal treating apparatus having a pot for holding a bath of molten metal, transfer means for moving the molten metal in the pot, including a molten metal-lifting passage having inlet opening means disposed in the molten metal for receiving molten metal into the metal-lifting passage, the metal-lifting passage having an outlet opening in the molten metal for discharging molten metal received in the inlet opening means, the metal-lifting passage having gas-injection openings upstream of the molten metal outlet opening; gas passage means for connecting a source of gas to the gas-injection openings in the form of a gas jet into the metal-lifting passage such that the gas induces a flow of molten metal from the molten metal inlet opening means toward the molten metal outlet opening, the improvement comprising:

the molten metal inlet opening means comprising a window in the metal-lifting passage disposed coaxially and/or laterally with respect to the path of motion of the gas flowing through the metal-lifting passage.

2. The improvement as defined in Claim 1, in which the inlet opening means comprises a plurality of windows disposed in an annular array around the path of motion of gas moving from the gas injection opening.

3. The improvement as defined in Claim 2, in which the gas induces the molten metal to move along an axis of motion from the inlet opening means towards the outlet opening, and the gas-injection openings are disposed to introduce a gas jet into the metal-lifting passage along said axis of motion.

4. The improvement as defined in Claim 1, in which said transfer means includes a tubular element for passing the gas to the gas-injection openings.

5. The improvement as defined in Claim 1, including a convergent/divergent nozzle in the metal-lifting passage downstream of the inlet opening means.

6. The improvement as defined in Claim 5, in which the metal-lifting passage has a linear upright inlet section, that connects very gradually through a large radii with a generally horizontal outlet section terminating with said outlet opening.

7. The improvement as defined in Claim 1, in which the metal-lifting passage has an elliptical cross section.

8. The improvement as defined in Claim 1, in which the gas is injected in a direction along the longitudinal axis of the metal-lifting passage.

9. The improvement as defined in Claim 1, in which the metal-lifting passage has inlet opening means disposed vertically below the outlet opening.

10. The improvement as defined in Claim 1, in which the gas is introduced as a jet such that the momentum of the gas pushes the metal along the metal passage.

11. The improvement as defined in Claim 1, in which the metal-lifting passage has an enlarged inlet end connected by a convergent nozzle to an outlet section having a smaller diameter than the inlet end.

12. A method for raising molten metal in a bath of molten metal comprising the steps of:

disposing a body having an internal molten metal-lifting passage, an inlet opening connected to the internal metal-lifting passage, in the molten metal for receiving metal into the metal-lifting passage;

introducing a gas at a lower position in the gas-lifting passage; and then

introducing molten metal through a coaxially and/or laterally spaced window into the metal-lifting passage such that the gas rises to move discrete elements of the molten metal up the metal-lifting passage.

13. In a metal treating apparatus having a pot for holding a bath of molten metal, transfer means for moving the molten metal in the pot, including a molten metal-moving passage having inlet opening means disposed in the molten metal for receiving molten metal into the metal-moving passage, the metal-moving passage having an outlet opening for discharging molten metal received in the inlet opening means, the metal-moving passage having gas-injection openings upstream of the molten metal outlet opening; gas passage means for connecting a source of gas to the gas-injection openings in the form of a gas jet into the metal-moving passage such that the gas induces a flow of molten metal from the molten metal inlet opening means toward the molten metal outlet opening.

14. A metal treating apparatus as defined in Claim 13, in which the metal-moving passage is substantially horizontal and elongated, and the inlet-opening means is at one end of the metal-moving passage and the outlet opening is at the opposite end of the metal-moving passage.

15. An apparatus as defined in Claim 13, including a window in the metal-moving passage disposed laterally with respect to the path of motion of the gas moving through the metal-moving passage.

16. An apparatus as defined in Claim 13, in which the metal inlet opening means comprises an opening disposed coaxially with respect to the path of motion of the gas moving through the metal-moving passage.

17. An apparatus as defined in Claim 13, in which the metal-moving passage has a divergent section between the inlet opening means and the outlet opening.

18. An apparatus as defined in Claim 13, in which the outlet opening has a horizontally elongated elliptical cross section.

19. An apparatus as defined in Claim 13, in which the inlet opening means comprises a manifold having a plurality of gas injection nozzles.

20. An apparatus as defined in Claim 19, in which the manifold has a plurality of legs disposed in the path of motion of the metal being received into the metal-moving passage, and the nozzle means are disposed in said legs to deliver the gas axially with respect to the metal-moving passage.

21. A pump for moving a liquid comprising:

a body having a liquid inlet port for receiving liquid from a liquid source, and a liquid outlet port, and an internal liquid passage fluidly connecting the liquid inlet port and the liquid outlet port for passing liquid therethrough;

the internal passage having a tapered passage including one end thereof defining said inlet port of a first diameter, and an opposite end defining an outlet port of a second greater diameter downstream of the inlet port; and

a source of a gas, and gas jet means disposed in the tapered wall to induce a flow of the liquid from the inlet port toward the outlet port.

22. A pump as defined in claim 21, in which the gas is delivered at an acute angle with respect to the flow of the liquid.

23. A pump as defined in claim 21, in which the gas is introduced axially in the direction of gas flow, adjacent the inlet port to induce liquid flow through the inlet port toward the outlet port.

24. A pump as defined in claim 21, in which the internal passage has a cylindrical cross-section.

25. A pump as defined in claim 21, in which the gas ports are below the outlet opening.

26. A pump as defined in claim 21, in which the liquid flows through the outlet opening along a generally vertical path of motion.

27. Apparatus for introducing a gas into a moving liquid comprising:

a body having a liquid inlet port for receiving liquid from a liquid source, and a liquid outlet port, and an internal liquid passage fluidly connecting the liquid inlet port and the liquid outlet port for passing liquid therethrough;

the internal passage having a tapered passage including one end thereof defining said inlet port of a first diameter, and an opposite end defining an outlet port of a second lesser diameter downstream of the inlet port; and

a source of a gas, and gas jet means disposed in the internal passage adjacent the inlet port to induce flow of the liquid from the inlet port toward the outlet port.

28. Apparatus for introducing a gas into a moving liquid stream comprising:

a body means having a tapered internal passage, and an inlet and an outlet for passing a liquid through the tapered internal passage;

a gas distribution means disposed in the body adjacent the tapered passage, the gas distribution means having conduit means connected to a

source of a gas, and nozzle means disposed in the body for delivering the gas into the liquid to induce a flow of the liquid through said internal tapered passage.

29. Apparatus as defined in claim 28, in which the nozzle means are disposed in an annular array around the path of the moving liquid.

30. Apparatus as defined in claim 28, in which the body means has a tapered inlet passage upstream of the gas distribution means.

31. Apparatus as defined in claim 28, in which the body means has a tapered outlet passage downstream of the gas distribution means.

32. Apparatus as defined in claim 28, in which the body means has an internal passage having an inlet passage which converges toward the annular gas distribution means, and an outlet passage which diverges from the gas distribution means.

33. Apparatus as defined in claim 28, in which the internal passage is adapted to pass a liquid along a flow path along an axis of motion, and the gas distribution means includes nozzles disposed in an annular array around said fluid flow and disposed to deliver the gas at an angle α with respect to said axis of motion.

34. Apparatus as defined in claim 33, in which α the angle between and the direction of gas flow and the direction of fluid flow is in accordance with the following relationship: $0° \leq \alpha < 30°$.

35. Apparatus as defined in claim 28, in which the body means has a divergent passage immediately downstream of the gas distribution means, the divergent passage having a frusto-conical wall formed with an angle α with respect to the direction of gas flow in accordance with the following relationship: $0° \leq \alpha < 30°$.

36. An apparatus as defined in claim 28, in which the apparatus is disposed to pass the fluid in a generally horizontal direction, and including an outlet duct connected downstream of the tapered passage, and the outlet duct has a generally S-shaped configuration so as to pass the gas from the pump upwardly and then in a generally horizontal direction.

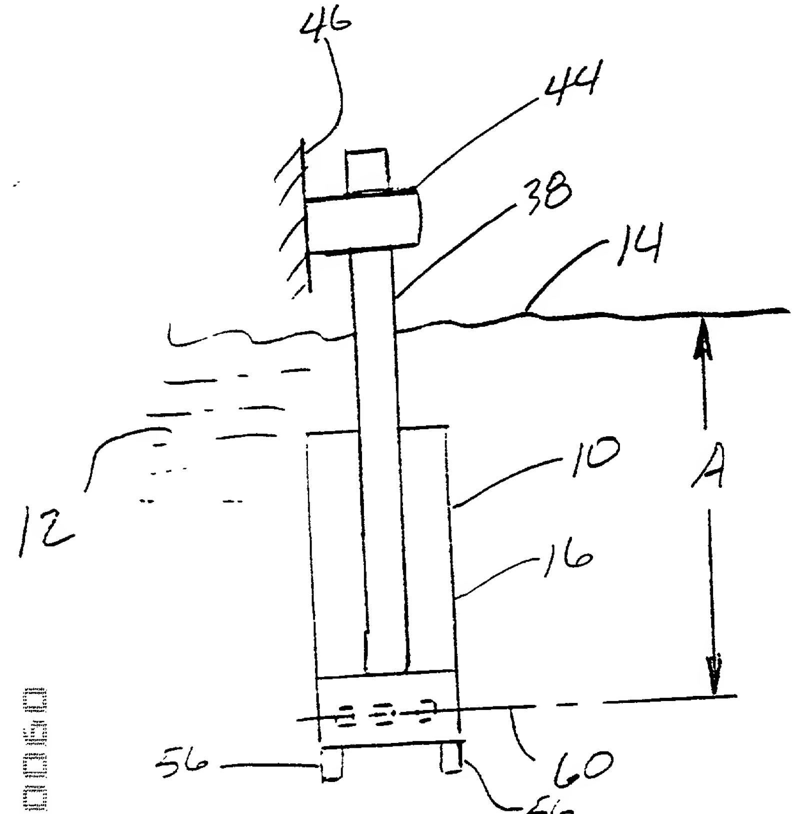


FIG 1

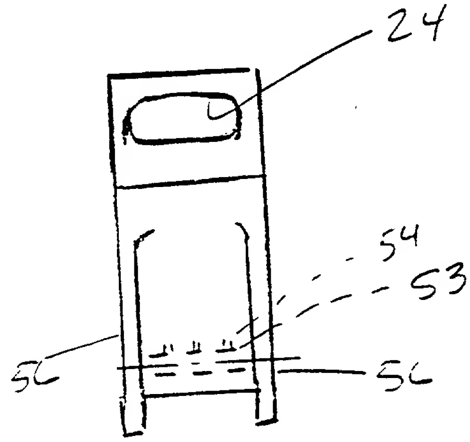


FIG 2

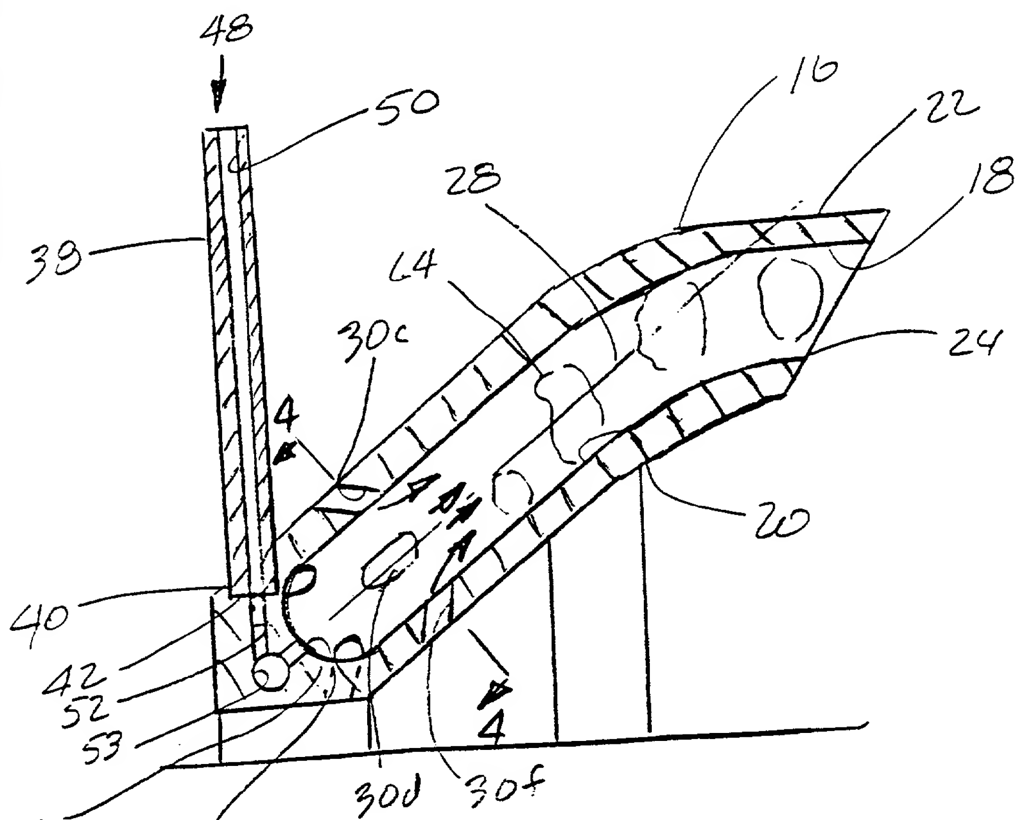


FIG 3

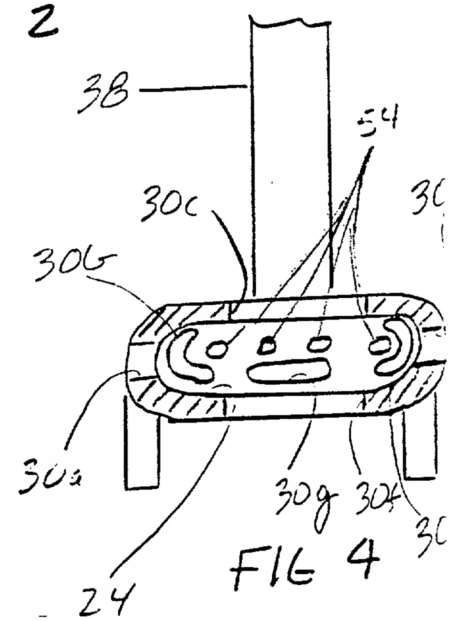


FIG 4

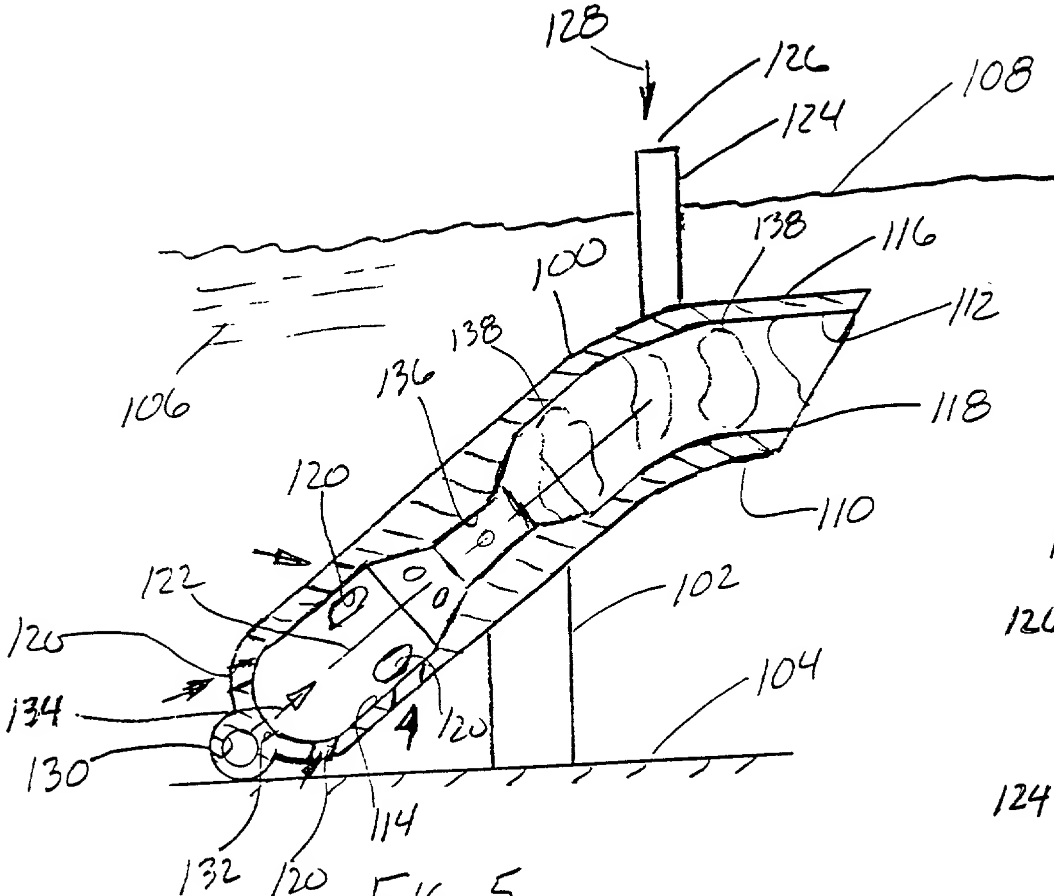


FIG 5

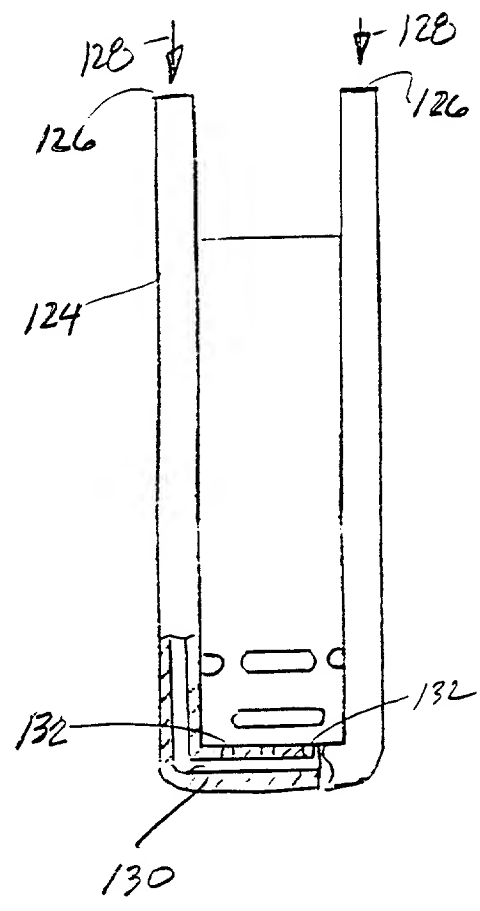


FIG 6

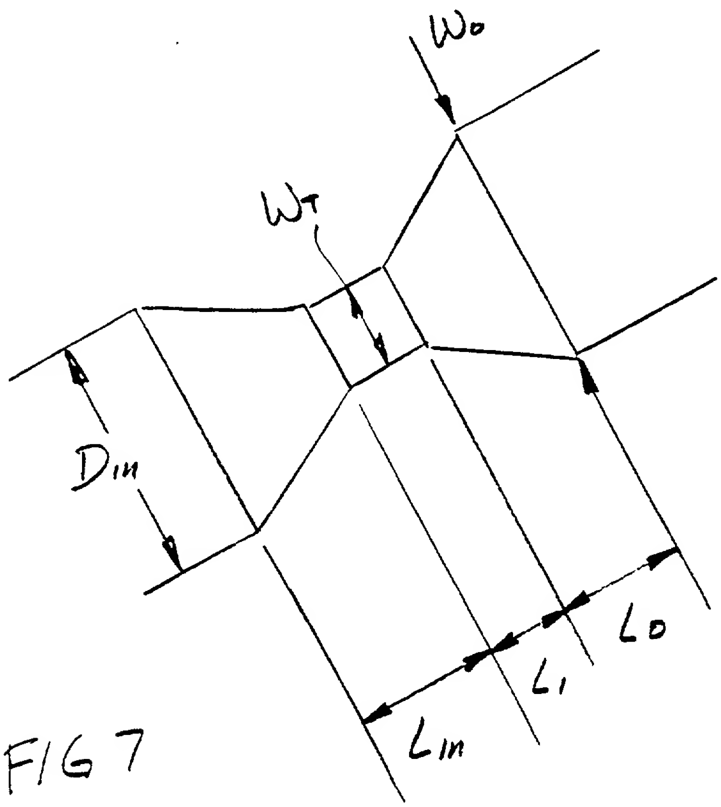


FIG 7

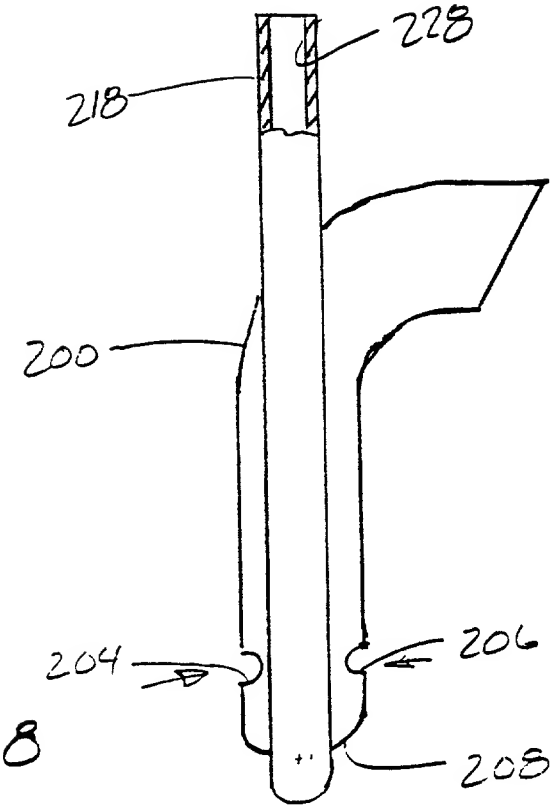
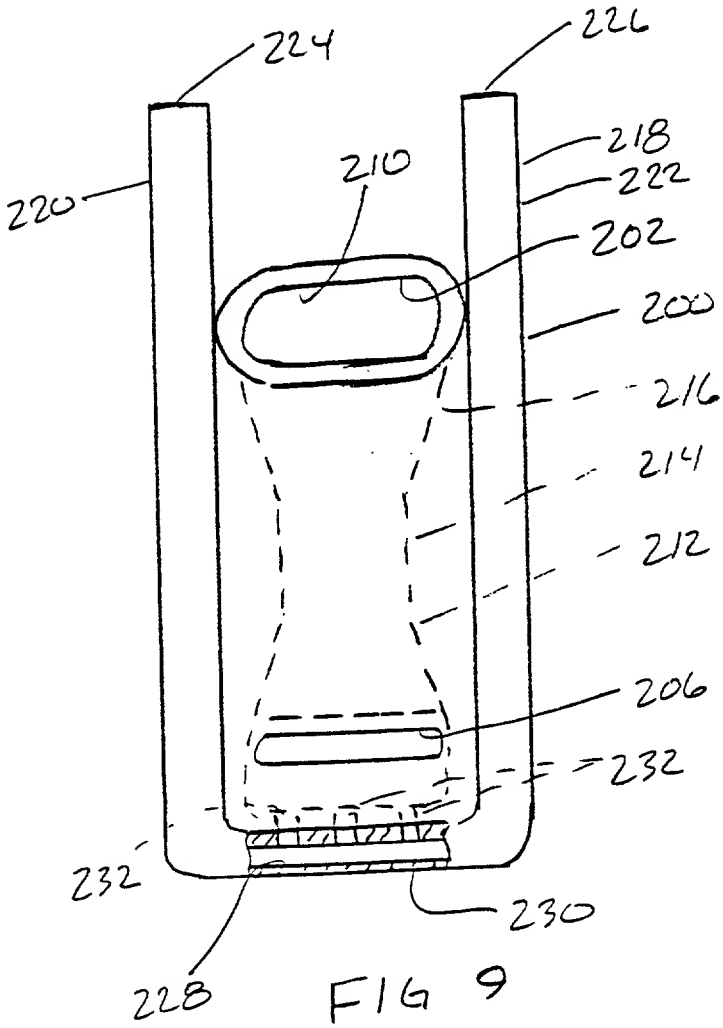


FIG 8



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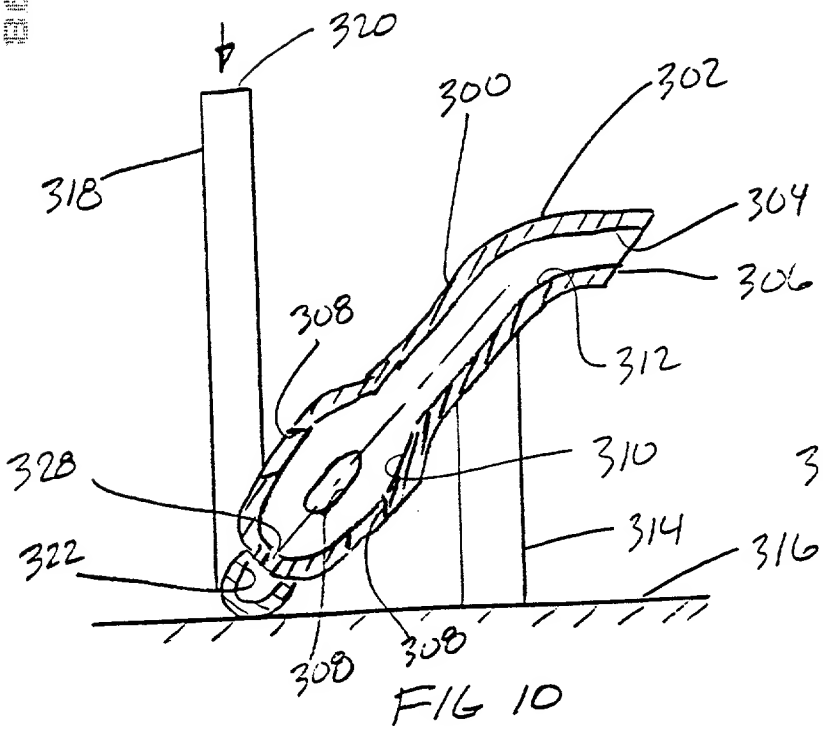


FIG 10

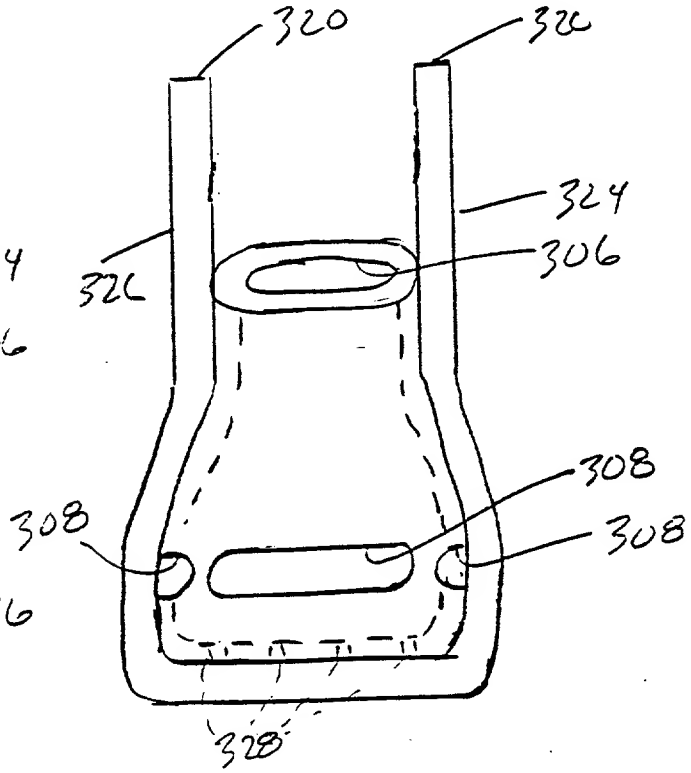
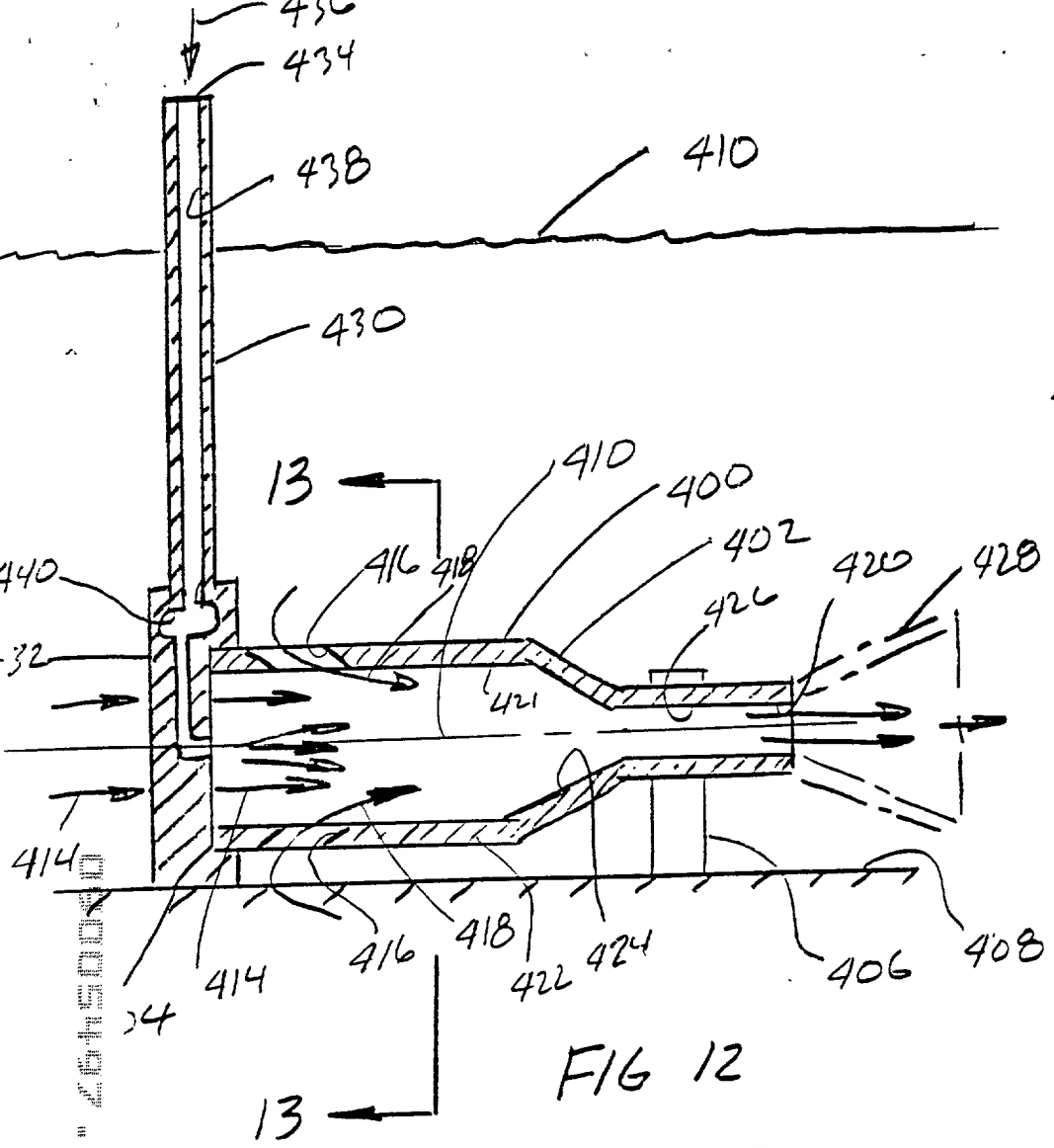


FIG 11



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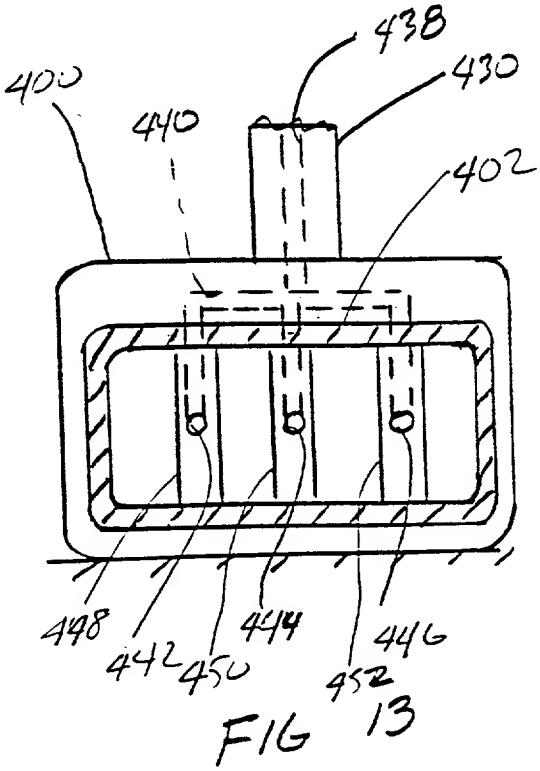

FIG 13

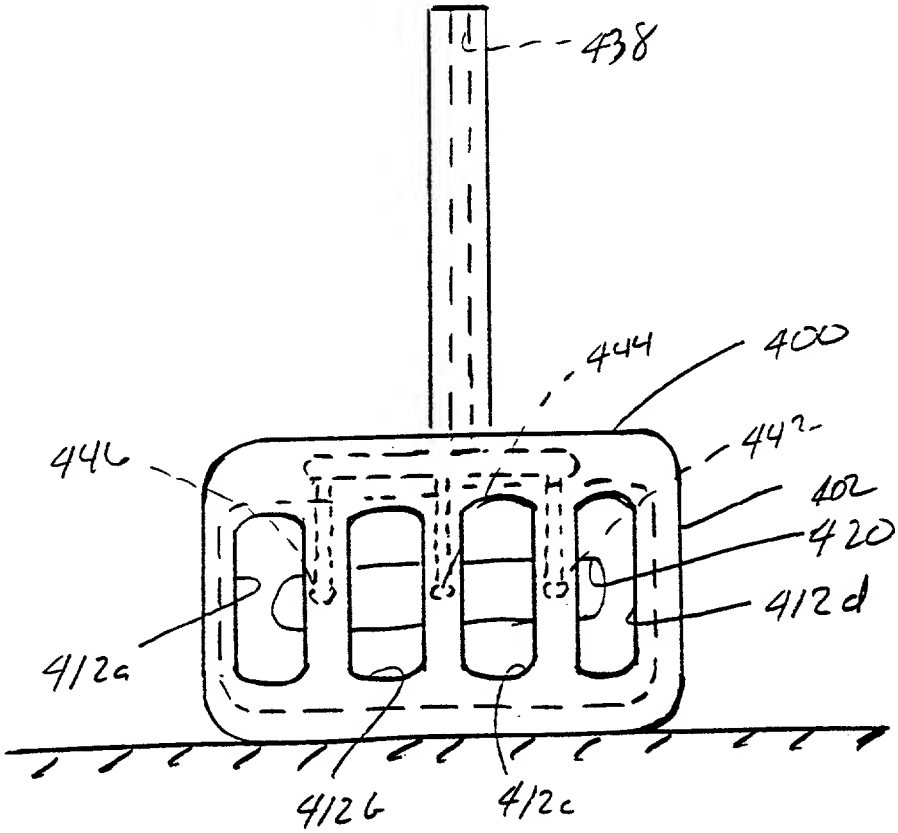

FIG 14

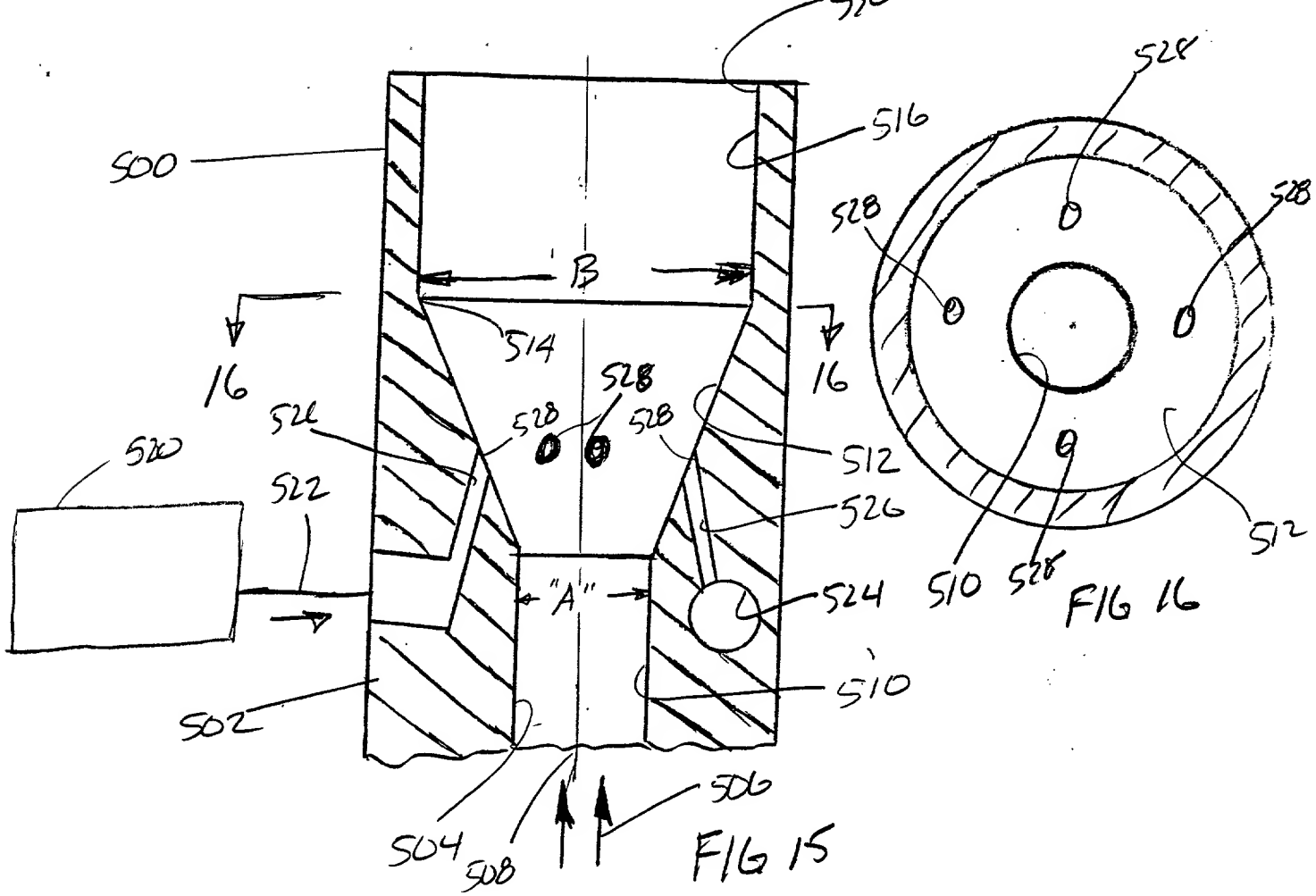

FIG 16

FIG 15

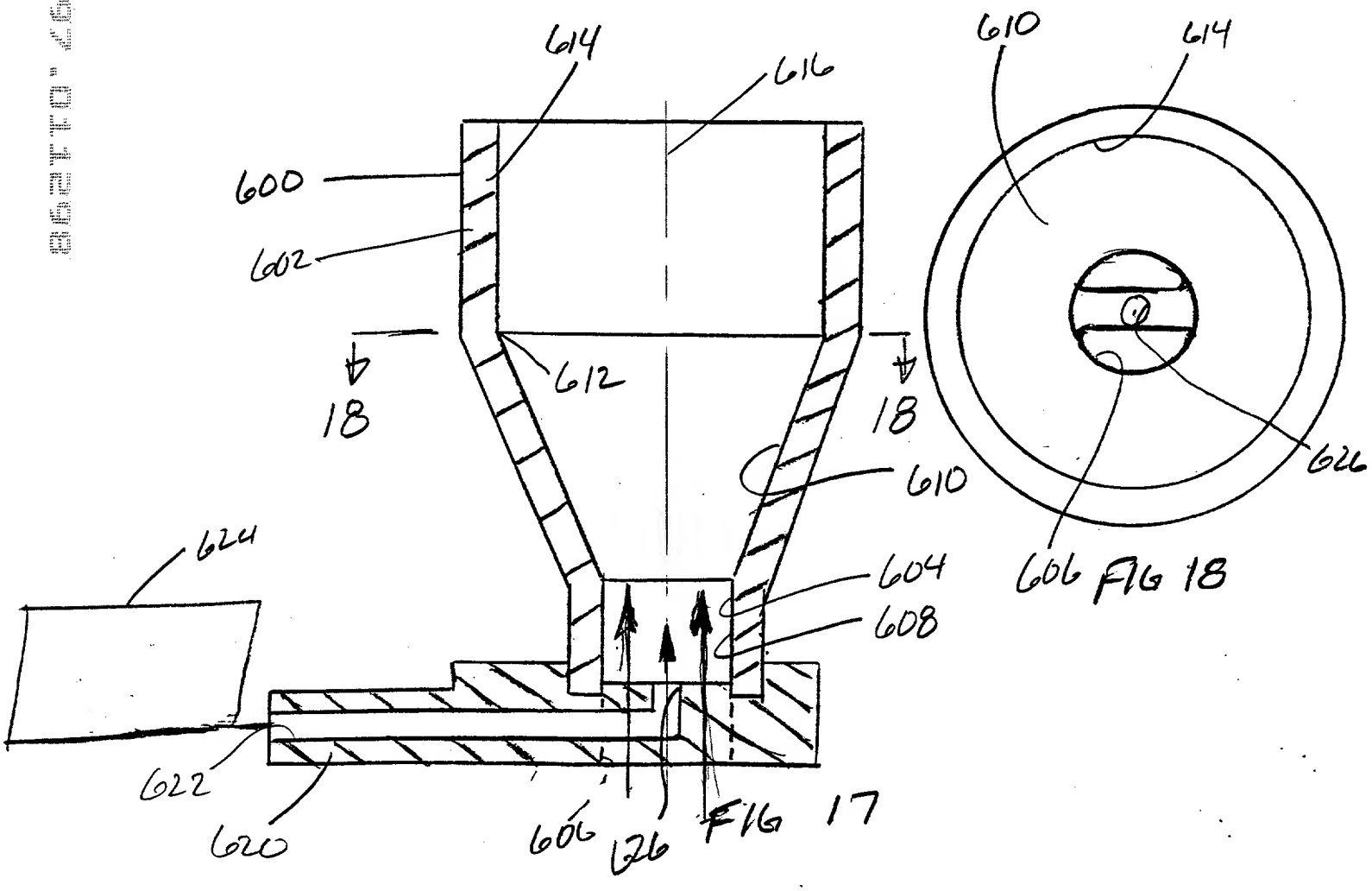

FIG 18

FIG 17

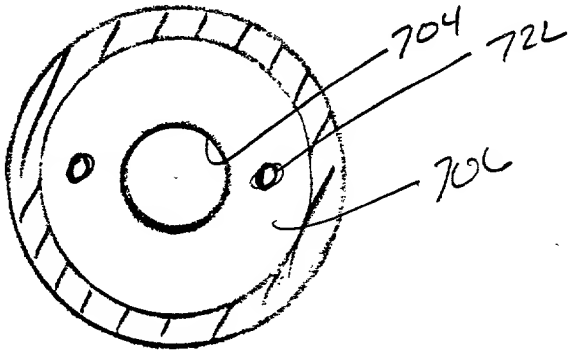
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FIG 20

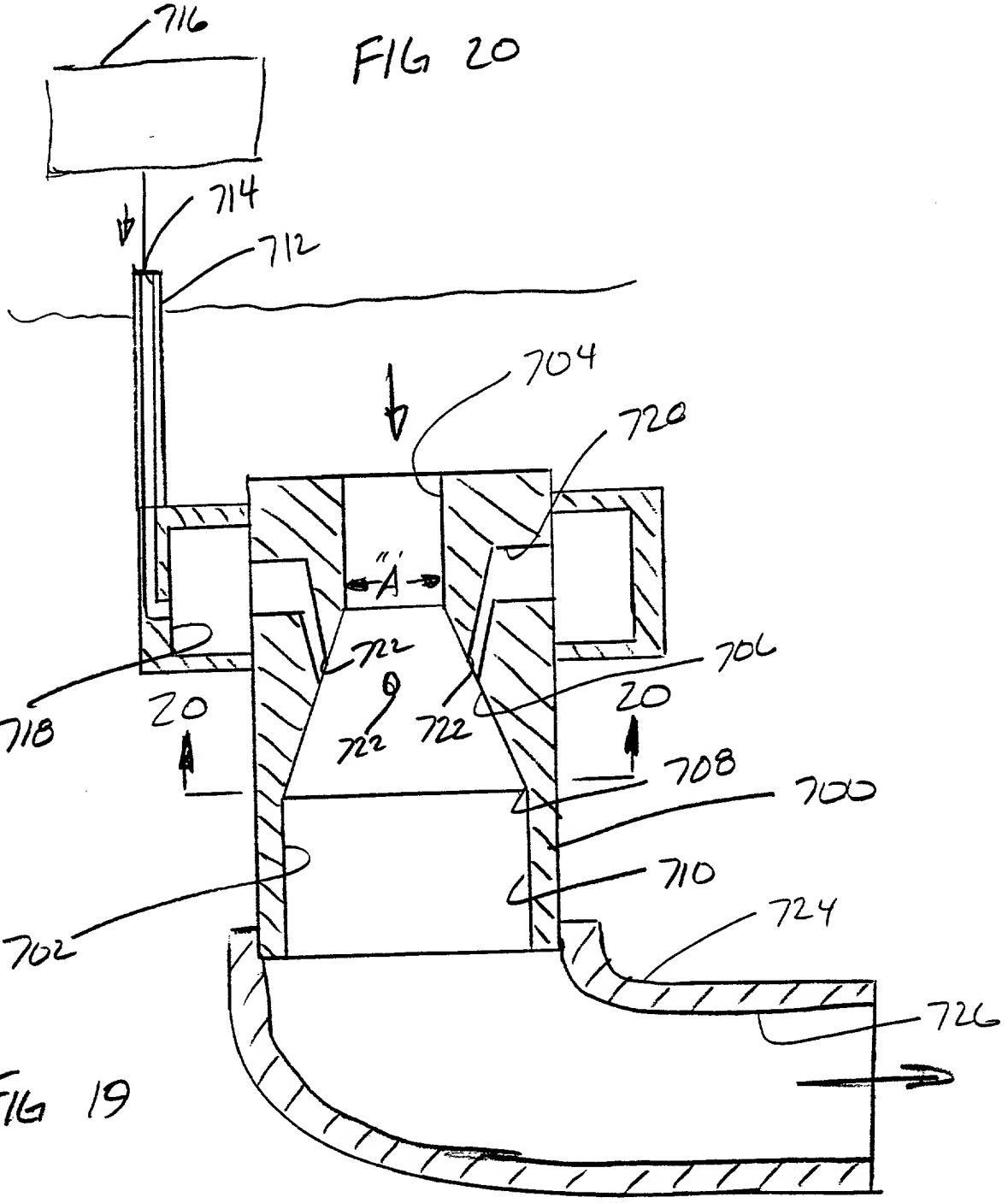
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FIG 19

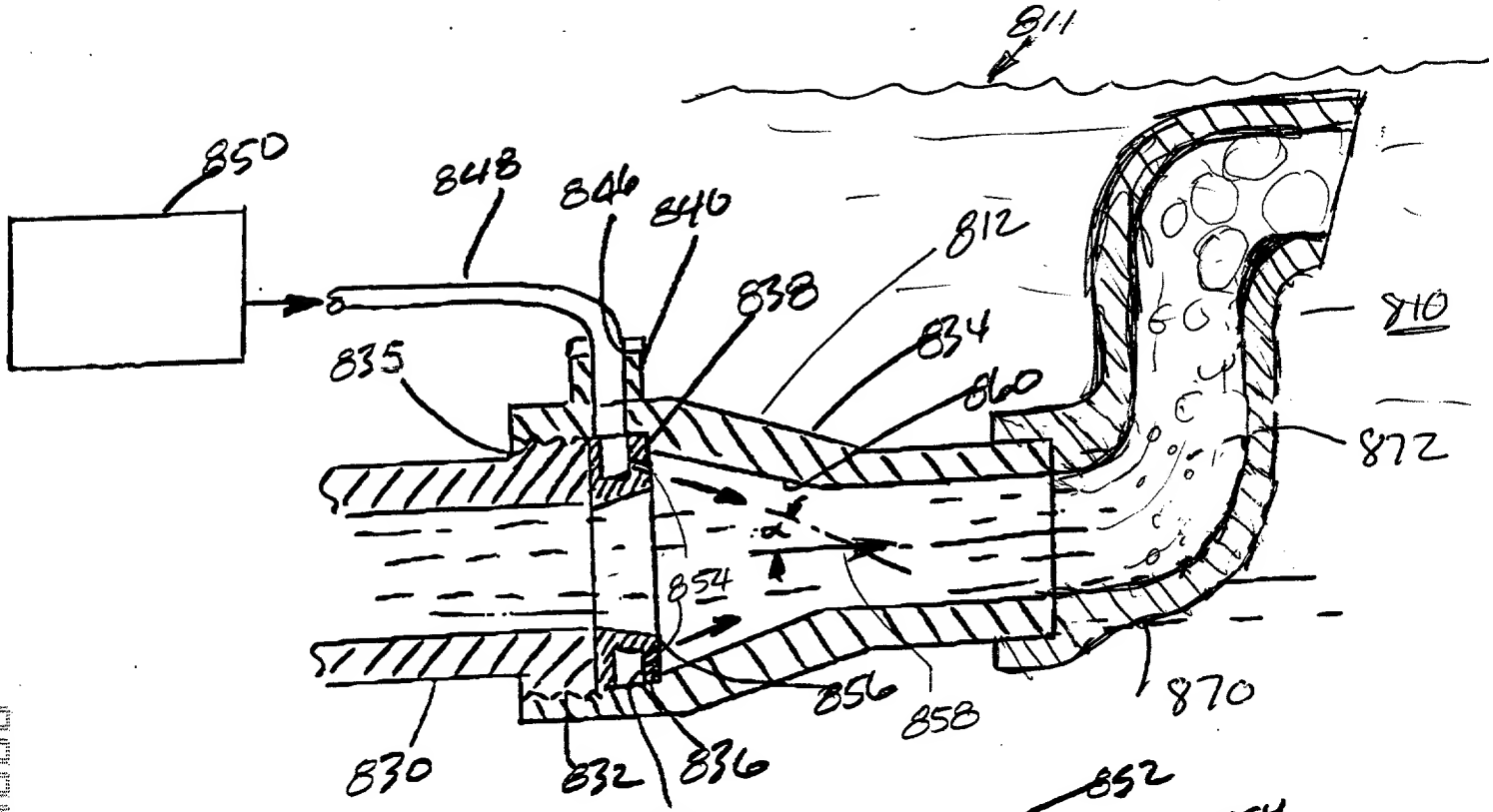

FIG 21

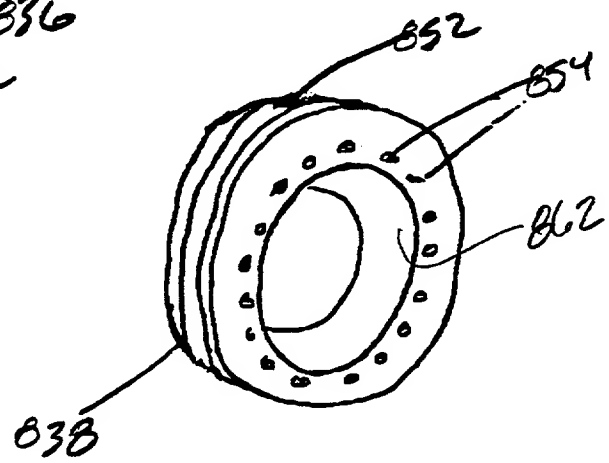

FIG 22

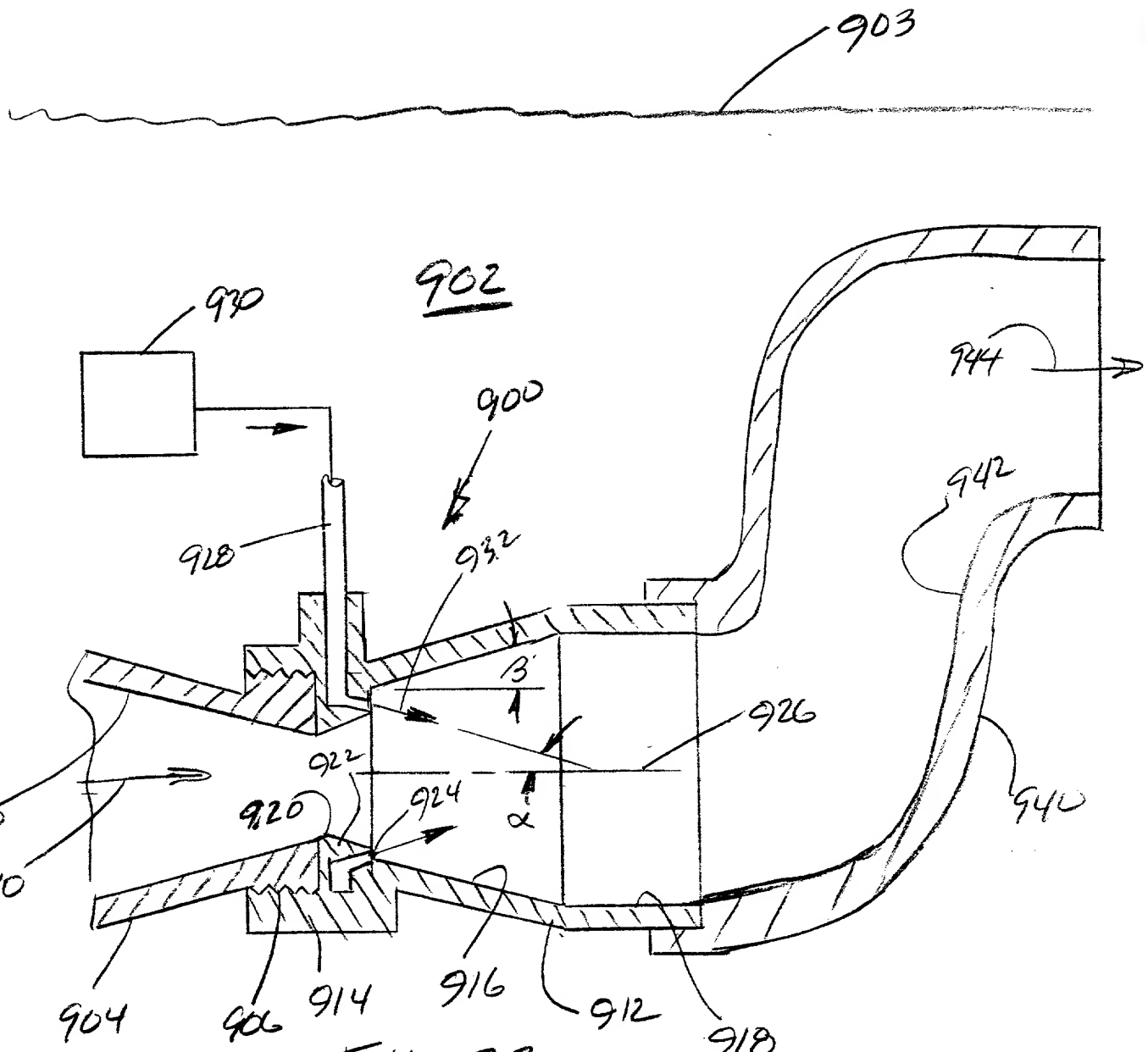
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FIG 23

PTO/SB/ 10 (6-95)
App for use through 07/31/96. OMB 0651-0031
Patent and Trademark ice: U.S. DEPARTMENT OF COMMERCE

VERIFIED STATEMENT CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) & 1.27(c))--SMALL BUSINESS CONCERN	Docket Number (Optional) MJV-108-B

Applicant or Patentee: Jorge A. Morando
Application or Patent No.:
Filed or Issued:
Title: JET COLUMN REACTOR PUMP WITH COAXIAL AND/OR LATERAL INTAKE OPENINGS

I hereby declare that I am

- ☐ the owner of the small business concern identified below:
- ☒ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF SMALL BUSINESS CONCERN Alphatech, Inc.
ADDRESS OF SMALL BUSINESS CONCERN 526 Riverview Trail
Cadiz, KY 42211

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.12, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees to the United States Patent and Trademark Office, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention described in:

- ☒ the specification filed herewith with title as listed above.
- ☐ the application identified above.
- ☐ the patent identified above.

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights in the invention must file separate verified statements averring to their status as small entities, and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern or organization having any rights in the invention is listed below:

- ☐ no such person, concern, or organization exists.
- ☒ each such person, concern or organization is listed below.

Metaullics Systems Co. L.P.
31935 Auroa Road
Solon, OH 44139-2717

Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING Jorge A. Morando
TITLE OF PERSON IF OTHER THAN OWNER President
ADDRESS OF PERSON SIGNING 526 Riverview Trail, Cadiz, Kentucky 42211
SIGNATURE J Morando DATE Dec 30 1997

Burden Hour Statement: This form is estimated to take .3 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231
DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

Approved for use through 9/30/98 OMB 0651-0032

Type a plus sign (+) inside this b -> [+] Patent and Trademark C U.S. DEPARTMENT OF COMMERCE

0010/PTO Rev. 6/95 U.S. Department of Commerce Patent and Trademark Office

DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION

☒ Declaration Submitted with Initial Filing OR ☐ Declaration Submitted after Initial Filing

Attorney Docket Number	MJV-108-B
First Named Inventor	Jorge A. Morando
COMPLETE IF KNOWN	
Application Number	
Filing Date	
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled :

JET COLUMN REACTOR PUMP WITH COAXIAL AND/OR LATERAL INTAKE OPENINGS

(Title of the Invention)

the specification of which

☒ is attached hereto

OR

☐ was filed on (MM/DD/YYYY) [ ] as United States Application Number or PCT International

Application Number [ ] and was amended on (MM/DD/YYYY) [ ] (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37 Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code §119 (a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365 (a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority sheet attached hereto:

I hereby claim the benefit under Title 35, United States Code §119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	
60/041,146	March 17, 1997	☐ Additional provisional application numbers are listed on a supplemental priority sheet attached hereto.

Burden Hour Statement: This form is estimated to take .4 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

Type a plus sign (+) inside this box → [+]

DECLARATION

I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s), or §365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application

U.S. Parent Application Number	PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)
08/733,078		10/16/1996	
08/489,322		06/12/1995	5,683,650

☐ Additional U.S or PCT international application numbers are listed on a supplemental priority sheet attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

☐ Firm Name OR ☒ List registered practitioner(s) name and registration number below: Customer Number or label

Name	Registration Number	Name	Registration Number
Charles W. Chandler	24,290		

☐ Additional registered practitioner(s) named on a supplemental sheet attached hereto.

Please direct all correspondence to: ☐ Customer Number or label OR ☒ Correspondence address below

Name	Charles W. Chandler				
Address	33150 Schoolcraft				
Address					
City	Livonia	State	Michigan	ZIP	48150
Country	U.S.A.	Telephone	(313) 522-0920	Fax	(313) 522-5657

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name	Jorge	Middle Initial	A.	Family Name	Morando	Suffix e.g. Jr.	

Inventor's Signature: Jmorando Date: 12/30/97

Residence: City	Cadiz	State	KY	Country	U.S.A.	Citizenship	U.S.A.

Post Office Address	526 Riverview Trail
Post Office Address	

City	Cadiz	State	KY	Zip	42211	Country	U.S.A.	Applicant Authority	

☐ Additional inventors are being named on supplemental sheet(s) attached hereto